MONITORING AND EVALUATING RESULTS OF BAT PROTECTION EFFORTS

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ABSTRACT

Many States are authorized to close abandoned mines to protect the public from potential hazards. In Utah, abandoned mines are surveyed prior to closure to evaluate their potential as bat habitat. Those mines providing suitable habitat may be sealed with bat-compatible gates that allow bats continued ingress and egress. However, a few studies suggest that for some population sizes and certain species of bats, bat gates may actually decrease bat use of mine openings; few post-gate monitoring studies exist to document long-term effects of this technique for conserving bat populations. In two areas we are monitoring and evaluating the effectiveness of gated mines on existing, known bat populations. Objectives include: evaluating and ranking the effectiveness of techniques [e.g., night vision devices, infrared event counters (Trailmaster 500M), infrared video, ultrasonic detection equipment (Anabat) and mist nets or harp traps] to monitor bat use; using this information to develop a protocol for using the most reliable of these techniques; and establishing long-term monitoring sites. Evaluation criteria include purchase and operating costs, security concerns, equipment reliability and ease of operation, number of personnel necessary to gather and evaluate the data, the ease of analyzing the data, and type of information needed. We suggest a combination of techniques to meet long-term monitoring objectives. Infrared event counters are well suited to record relative bat activity inside mines over long periods of time with minimum observer disturbance and cost, but cannot be used to reliably gather information on bat behavior through gated entrances, or absolute numbers and species identification of bats. Ultrasonic detection equipment and mist net/harp traps are necessary techniques to reliably determine bat species composition. Infrared video cameras provide an accurate, permanent monitoring record of bat numbers and behavior. Protocols specific to each mine may be necessary to minimize observer and equipment effect on bat behavior. Efficient low cost monitoring can be accomplished using minimal equipment and personnel. Preliminary analysis suggests that bat behaviors do differ in gated and un-gated mine openings.

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INTRODUCTION

Concern over bat populations has been increasing in recent years and many bat species appear to be declining (Stebbings 1980, McCracken 1988, Tudge 1994). Of the 43 United States bat species, five are listed by the USFWS as endangered and 19 are former candidates for listing (Code of Federal Regulations 1991). Because bat populations appear to be declining, many agencies now recognize bats as a valuable species, worthy of inclusion in management decisions. Unfortunately, detailed data are lacking, and the present status of many bat species remains unknown (McCracken 1989). In addition, adequate funding is often unavailable to determine long-term trends in bat populations.

One of the primary causes of declining bat populations may be the loss of suitable habitat. However, in recent years, many cave dwelling bats have increasingly been found in abandoned mines (Pierson 1989, Brown and Berry 1991, Pierson and Brown 1992, Brown et al. 1993). This increase has largely been attributed to the dislocation of bats from caves due to an increase in recreational caving, and the commercialization of many caves formerly identified as bat roosts (Tuttle, 1979, Brown and Berry 1991). Twenty-six of the 43 U.S. bat species are now known to roost regularly in abandoned mines (Pierson et al. 1991, Tuttle and Taylor 1994). Of the 18 Utah bat species (Hall 1981, Zeveloff 1988), 14 species regularly occur in mines. Ten Utah bat species are former Category 2 (C2) candidates for federal listing (Federal Register 1994), of which eight species inhabit mines during some time of the year. As with caves, abandoned mines offer bats a stable microclimate and possibly reduced risk of predation (Belwood and Welch 1991, Tuttle 1993). Recent studies have shown abandoned mines throughout North America are being used for a variety of roosting needs including, maternity, hibernation and day and night roosts (Tuttle & Taylor 1994).

In Utah and elsewhere in the West, abandoned mines are being sealed to protect an increasingly curious public. In the Silver Reef mining district, located in southwestern Utah, over 140 abandoned mine openings have been closed with bat compatible gates or grates on public lands administered by the Bureau of Land Management Dixie Resource Area, the Dixie National Forest and lands in private ownership within the Silver Reef Historic Mining District. Prior to the gating effort, a graduate student from Utah State University conducted a warm and cold season survey in an effort to identify bat species and general use patterns within these mines. The study found extensive bat use throughout the area, including a large maternity colony of Townsend's big-eared bat (*Corynorhinus townsendii),* a Utah state-sensitive species (Lengas 1996). Eighty miles north of Silver Reef, is the Tushar Mountain Mining area, where abandoned mine openings are scheduled to be closed in the fall of 2002. Surveys in this area have also found evidence of extensive bat use including Townsend's big-eared bat (*Corynorhinus townsendii),* and a maternity colony of the long-legged Myotis *(Myotis volans).*

Although gating mines may offer a probable solution to protecting known bat habitat and decreasing human disturbance at roosts, few surveys have been conducted regarding long-term effectiveness and impacts of gate designs on bat populations. The high concentration of abandoned mine closures and the existence of pre-closure survey data make both Silver Reef and the Tushar Mountain mine areas ideal sites for evaluating the long-term effectiveness of bat compatible gates to further aid land managers in bat-gate decisions.

Study objectives include:

- Documentation of seasonal, monthly, and daily bat activity patterns for a selected group of gated and un-gated mines
- Identification of bat species using this group of gated and un-gated mines and monitoring bat population trends in these mines

This discussion will focus on the findings for the following objectives:

- Evaluation of external monitoring techniques for assessing bat activity at the mine entrances
- Collection of baseline data to compare bat use of both gated and un-gated mines.

METHODS

Study Area : Two mine areas in southwestern Utah were used for this study, one with gated mines and one with un-gated mines. The Silver Reef and East Reef area underwent mine gating and closure starting in 1995, while mines in the Tushar Mountain mine area are scheduled for gating in Fall of 2002. The Silver Reef and East Reef mine areas are located in the Mojave Desert eco-region, at its transition to the Great Basin eco-region, at 3500 feet elevation. These reefs are located in sedimentary rock layers west and east of Leeds Utah. The Tushar Mountain mine area is situated in a coniferous and mountain brush canyon between 7000-8000 feet elevation. This mining district is located in conglomerate rock layers northeast of Beaver Utah.

Criteria for the gated mines chosen for monitoring in Silver Reef/East Reef (WH-48, WH-180, and G4-HO7) were known bat activity and accessibility (M. Mesch pers. com. and Lengas 1996, Silver Reef report 1999). G4-HO7 was not gated until November 2000. External surveys were also conducted at three un-gated mines in the Tushar Mountains (Rob Roy, 270753HO1; Mystery Snifter #2, 270628HO1; and Prince Mine, 270634HO1) east of Beaver Utah. The same combination of visual, video, acoustic and trapping techniques were used at gated mines and un-gated mines beginning in May and ending in October.

Sampling days were chosen as close to the new moon phase as possible to minimize possible effects of moonlight on bat behavior. In order to minimize the effects of weather on bat activity, simultaneous observations were made on gated and un-gated mines for three hours on three consecutive nights.

Bat activity and species composition were additionally assessed at each gated and un-gated mine location by mist netting a week after survey dates. Trapping was delayed to minimize disturbance effects on bat activity. Although most mines were netted monthly, the two mines with maternity colonies were netted only in the month of August after the critical reproductive times.

Several types of survey instruments were used to maximize observations of bat activity at both gated and un-gated mines (Table 1 and 2). During each survey, each mine had one to four observers present using a night vision scope, a lap top computer with Anabat™, a pre-installed Trail Master® infrared event counter (at the Silver Reef and East Reef mines only), two max/min thermometers, and a Sony™ Hi-8 digital infrared camcorder. All equipment was set up before 8:00 p.m. and camcorders were started at 8:30 p.m. and ended at 11:30 p.m. in order to document initial evening bat activity. Survey times began a half hour earlier in September, because of earlier sunset times. The following descriptions document use of techniques:

<u>Infrared Event Recorders (Trailmaster 500M ™ 1500's):</u>

Infrared event recorders ™ (TM) consisting of an infrared light transmitter and receiver/data logger were placed inside each gated mine for permanent monitoring of relative levels of bat activity year-round independent of observers. Because of theft concerns, these event recorders were not used in the un-gated mines. A single event was recorded as a hit on the receiver when an object (such as a flying bat) passed through and disrupted the vertical IR beam between the two components. Transmitters were placed on the roof of the mine approximately 4 to 6 feet directly above the receiver on the floor of the mine. The receivers were mounted on top of 8 inch spools on the mine floor. The elevation minimized rodent disturbance to the TM. The TM's were left in place 8-10 meters inside the mine entrance and monitored from 2000 to 2002. The event recorders were downloaded and batteries were replaced monthly to prevent data loss to power failure. Data was grouped in 5minute periods using SASS Macros for graphical analysis.

Red light:

Flashlights fitted with a red cellophane covering were used for observation when no other visual aids were available. The lights were placed to shine across the mine entrance, but not directly into the mine. The numbers of bats seen entering and exiting each mine were recorded by observers sitting 5 to10 meters from the mine entrance. Observer distance was estimated, based on previous observations, as being close enough to observe bat activity at the mine entrance with the least amount of bat disturbance.

Night Vision Scopes:

In 2000, observers used night vision (7-Bravo generation-3™ or ITT 260 Night Quest™ binocular) scopes to record bat activity at mine entrances. Observers sat 5 to 10 meters from the mine entrance, and recorded bat entrances, exits and other behaviors such as circling inside the mine and flying past the entrance. In 2001, observers moved 25-30 meters away from the mine openings to minimize observer effect on bat activity. Night vision scopes were used only to record bat behavior in the general area but not bat activity in the mine adit.

Remote (I Spy™) Monitors:

Remote monitor cameras (I-Spy™) surveillance system were also used to indirectly observe bat activity at mine entrances. The camera lens was placed on the tripod along side the video camera. The receiver TV monitor could be placed as far as 30 meters away so the observers could watch bat activity with very little observer impact.

Digital infrared camcorders :

Digital infrared camcorders (Sony nightvision ™ Hi-8) were used to record bat activity at the mine entrances. This allowed for a permanent record of survey data and more complete analysis of bat behavior at entrances. To minimize mine entrance obstruction, each camera was placed on a tripod, nestled near a rock or mine sidewall. Each camcorder had one attached infrared (IR) light with an extra IR light spotlight (Sony HVL-IRH2™)) source nearby. This setup minimized the effect of camera presence but still included the whole mine entrance in the camera viewfinder. The Hi-8, 120-minute digital tape yielded approximately 1 hour of recorded data, and three tapes were used per mine each night. The tapes were transferred to VHS tape after the sampling sessions and analyzed for: recording time, bat entrances, exits, circling and flyby behavior event numbers. Taping began approximately 30 minutes before sunset and continued for three hours (2030-2330, May-August, 2000-2300 September)

Anabat™ ultrasonic bat call detectors:

To aid in species identification, Anabat™ detectors were positioned on tables or on the ground approximately 10 meters in front of or to the side of a mine entrance, depending on the topography of the surrounding area. All bat calls >10 seconds long were recorded to document bat activity. Bat calls matching bat movements in or out of mine were documented for use in species identification. In addition, calls were recorded when captured bats were released and added to the species identification library for these mine areas.

Trapping:

Trapping was used at both mine areas to identify bat species using the mines. Mist nets were set as close as possible outside mine entrances to capture bats entering and exiting mine entrances. Captured bat measurements included weight, sex, reproductive status, body dimensions, and age to develop site-specific life history information.

Weather measurements:

Because seasonal differences in bat activity may be a result of unusual weather events during sampling, ambient temperature was measured during sampling periods and throughout the year. Max-min thermometers were placed at mine entrances and survey stations during each survey night, while temperature data loggers (Hobo® H8) were permanently installed 10-12 meters inside the gated mines and temporarily placed outside the un-gated mines. The un-gated mine loggers were was downloaded at the end of the season. The gated mine loggers were downloaded monthly throughout the entire year.

Internal mine surveys:

In 2001, four bullet (size) camera lenses with infrared spotlights were installed inside the gated WH-180, to monitor the maternity colony area. Power and video cables were run from each camera through an adjacent shaft and left in place for hookup to a Sony Nightshot™ camcorder and external power source. Once per week May through June one hour of tape was recorded, alternating 5-minute recording cycles at each of the four cameras. These tapes were transferred to VHS tape and analyzed for bat numbers and species composition. In addition, plastic sheets were laid in the possible high-use areas to sample guano deposits.

In August of 2001 and 2002, internal mine surveys were conducted at the gated mines to estimate bat population numbers and locate specific roost use areas. Two observers surveyed all mine workings and determined numbers and distribution of bats through direct observation and documentation with a digital camera and Sony Nightshot™ camcorder.

Results

Comparison of Equipment recording bat numbers

The total number of events, i.e., bat entrances, exits plus circling, recorded using different monitoring techniques, varied substantially. In general, the camcorder video and TM event recorder detected the largest numbers of events. Sometimes totals were similar but other times the totals were very different (Figure 1). For most months in most mines, the number of events recorded on the infrared video doubled (and even tripled in one instance) the number recorded using other detection equipment. More importantly, using red light only for observations appeared to substantially increase variability in counts. For example in 1997, visual counts of bat events at the gated mines averaged 32 $\pm$ 45 per hour (Andrus 1997).

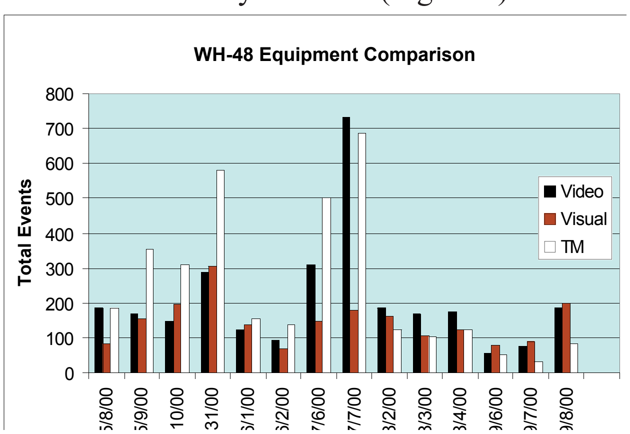


Figure 1. Comparison of total bat activity events recorded by three types of equipment: Infrared video camcorder (Video), Infrared goggles (Visual), and Infrared event counters (TM).

Different survey times show different in bat numbers using mines throughout the year. For example, both videotape analysis and night vision scope observations recorded consistently high average bat numbers (greater than 20 bats) at gated mines during April through September, and low levels of use before April and after September (Figure 1). Two gated mines and one un-gated mine showed consistently high average bat numbers

(>15 bats per survey hour). One gated and one un-gated mine consistently showed the lowest average bat use (>6 bats per survey hour).

Data from the TM recorders indicate that total bat numbers at gated mines varies throughout the season (Figure 2), and can be used to compare relative numbers using mines

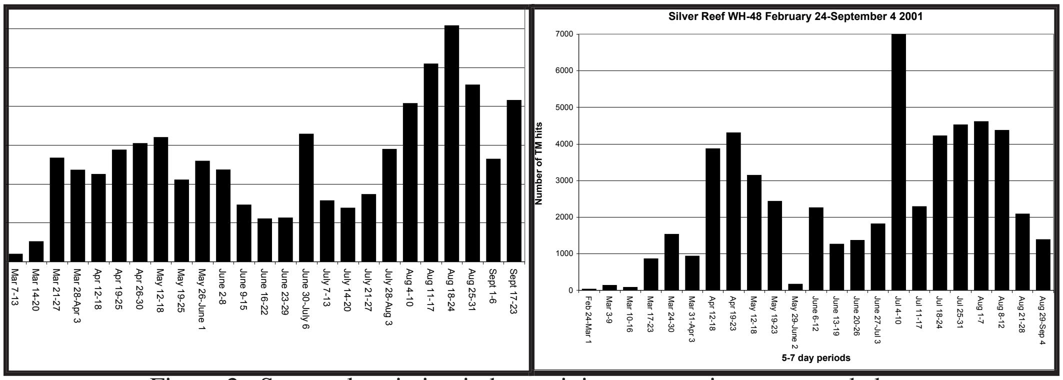


Figure 2. Seasonal variation in bat activity at two mines as recorded by infrared event counters (Trailmaster TM).

between years. The total number of events from the year at one gated mine peak just after sunset and just before sunrise throughout the spring and summer months (Figure 3).

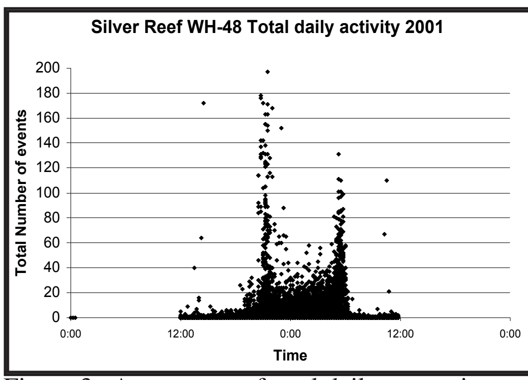
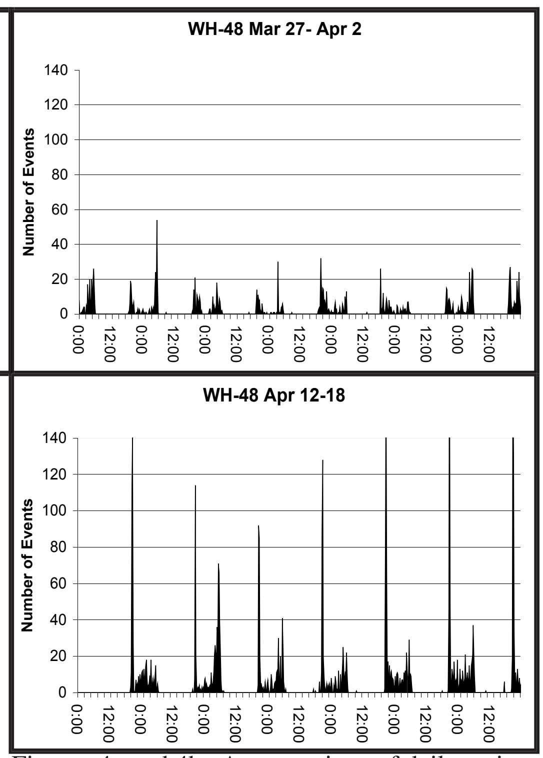


Figure 3. A summary of total daily events in a mine for one year as recorded by an infrared event counter.



Figures 4a and 4b. A comparison of daily activity patterns in a mine during different weeks as recorded by an infrared event counter.

However, the number of events varied between days of the week (Figure 4).

Bat information from internal survey and internal camera

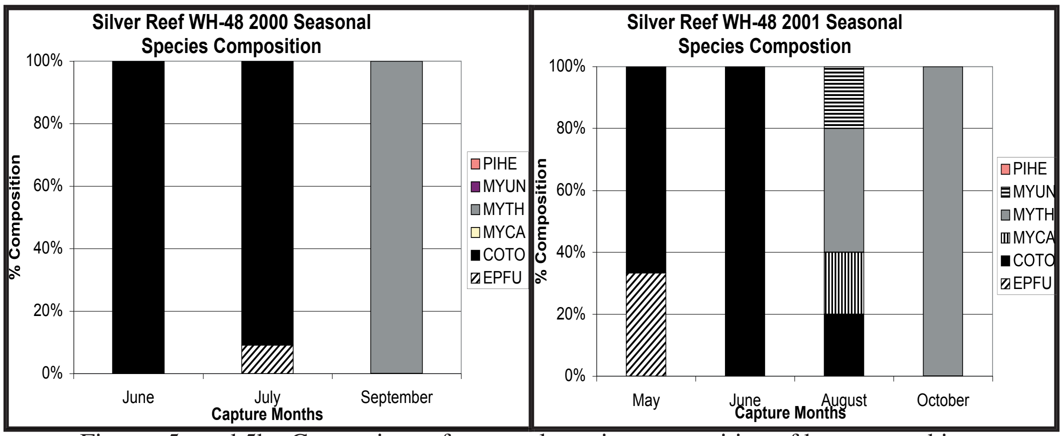
Less than five bat flybys were recorded through the four cameras set up inside the maternity colony mine, and no bats were observed using the maternity roost site used in 2000.

In the internal survey, a large amount of guano was found in a smaller adjacent stope, but there was relatively little guano on the plastic sheets in the area of the maternity roost. Only six Townsend's big-eared bats (no juveniles) were observed roosting throughout the mine. In the other gated mine approximately 150-200 Townsend's big-eared bats (with at least 6 juveniles) were observed roosting in a very large stope near two shaft openings to the west of the adit.

In both mines, bats were seen roosting in the upper drift levels only. Ringtail (cat, *Bassaricus astutus*) scat was found throughout the old maternity colony location, and a large amount was found at the new maternity roost location (away from internal cameras) within the mine complex. Ringtail scat was also found in concentrations in the lower drift level of the other gated mine. Ringtails were also observed at and on the gates during external surveys at both mine entrances.

No bats or ringtail scat were found in the newly gated mine, but bat guano and moth parts were scattered throughout the mine.

Both trapping and acoustic records for bat species identification show that bat species number and composition varies between months in each mine (Figure 5).



Figures 5a and 5b. Comparison of seasonal species composition of bats trapped in mist nets placed across mine portal at Silver Reef gated mine WH-48. Percentages do not represent equal trap effort.

In both areas there is a pattern of different bat species consistently captured during specific times of the season. For example, at gated mines, Townsend's big-eared bats were captured in all months except October, big brown bats were not captured in June and October, and *Myotis* species and western pipistrelles were captured only in August or later. Trapping success was varied considerably in different mines and different years. For example, in 2001, 5 species (8 individuals) (Townsend's big-eared bats (*C.townsendii*), big brown bats (*E. fuscus*), California myotis (*M. californicus),* western small-footed myotis (*M. ciliolabrum),* and fringed myotis (*M. thysanodes)*) were captured at one gated mine, one to two species were captured at another gated mine, but no bats were captured at the third mine. However, we were able to identify species using internal surveys, acoustic records and videotapes: *Myotis* species were seen in two internal surveys (2000 field notes), and Townsend's big-eared bats were seen in videotape surveys and recorded on Anabat® (2001 field notes).

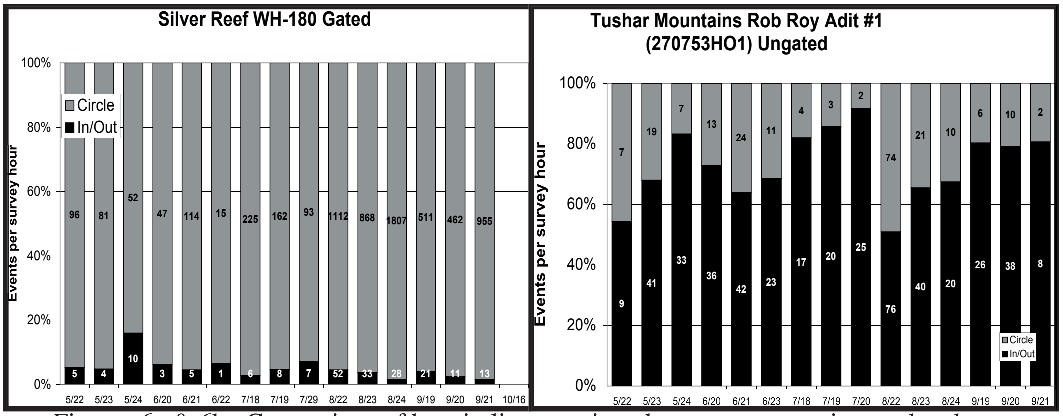
Accurate evaluation of bat status can only be determined from trapping. For example, the species and status of bats captured at un-gated mines included long-legged myotis *(M. volans)* gravid females, lactating females and sub-adult males.

Effect of bat gates on bat activity

In 1999-2001 field seasons, proportionately more circling bats were seen for longer periods of time in gated mines than in un-gated mines (Figure 6). The ratio of bats circling to in-and-out behavior averages 1:1 in un-gated mines and is usually greater than 5:1 in gated mines (Figure 6). In one gated mine, bat circling to in-and-out behavior ratios were consistent throughout the season (10:1), but in another this ratio varied from a low of 1:2 increasing to 10:1

in June through July and decreasing to 3:1 August through October (Figure 5).

In contrast, bat circling to in-and-out ratios were low (0:1-4:1; Figure 13) in the Tushar Mountain un-gated mines with only slight variability. Peak bat circling ratios were in August and September (Figure 6).



Figures 6a & 6b. Comparison of bat circling to exit and entrance events in gated and un-gated mines as recorded by infrared video camera in 2001.

Similarly, before gate installation in the East Reef mine, bats exhibited a low circling to in-and-out ratio (1:3). However, after gate installation, the circling to in-and-out ratio increased to a high of 10:1; and bats were observed using the crack above the gate for the first time.

In all years, at least 85% of bats entered and exited the gates through the top 1/3 of the gate bars or the top part of the portal in the un-gated mines (1999, 2000 and 2001 field notes).

Discussion

Equipment comparison: Although red-light assisted observations can detect relative use/non-use of mines by bats, the increased clarity of night vision infrared scopes and infrared video cameras allow observers to distinguish between actual bat entrances and exits (Figure 1). This data provides a more accurate picture of relative numbers of bats using the mines and differences in their exit and entrance behaviors in gated and un-gated mines. Use of the night vision scope, however, required an additional timer/recorder person. In addition, after a 30 minute continuous viewing period, using the night scope observer was subject to vision fatigue, making an accurate record for the four-hour sampling period problematic. Monitoring and analyzing bat activity at mine entrances was most detailed and accurate with the infrared video camera, because of the combined night vision view with a permanent record tape, which could be paused and re-played to clarify actual behavior. Bats can also be identified as large bats or small bats. The necessity of changing tapes every hour does introduce possible disturbance effects. Infrared event counters (TM1500™) can be left in place to collect data continuously for at least one month (longer when activity rates are less) before being downloaded. Thus TM's provide the most information on long-term activity patterns with the least amount of disturbance potential affecting bat behavior. Unfortunately, the nature of the events recorded cannot be determined from the event recorder, so the events may be triggered by bats flying in or out of the mine, and birds or small rodents passing through the beam. Thus, numbers generated by TM data reflect relative activity per time, and may include the same bats flying back and forth (circling) inside the mine. In addition, bats will fly around the TMs when they are initially installed in the mines (video observation), thus short-term data gathered by TMs may not be comparable to long-term TM data.

Species Composition: Numbers of bats trapped in Silver Reef and East Reef continue to decrease as compared with 1999 and 1998 . For example, July 1998, 24 Townsend's big-eared bats were netted; however in 2000 and 1999 only ten and eleven, respectively, were netted during a similar time period. Because most of the Townsend's big-eared bats captured in July were sub-adults, and overall few adults have been trapped since the first year of trapping, the decrease in numbers may not reflect an actual population decrease, but because bats are long-lived and extremely aware of their environment, there may be a learned avoidance response on the part of adult bats. Since the gates were installed in 1997 and monitoring began in 1998, there have been no obvious changes in numbers of bats seen exiting or entering mines or in activity levels as measured by TM event recorders. Numbers of bats seen in internal surveys have also been consistent. However, the level of monitoring has varied considerably, so the level of uncertainty in regards to population trends remains high. In addition, since species identification is partially dependent on trapping, identification of bats using mines becomes even more difficult. Anabat™ recordings continue to provide a record of bats in the area, but this identification tool is problematic for quiet bats, and bats whose calls are less species distinctive. We have observed, for example, that Townsend's big-eared bats usually do not call as they are seen exiting or entering mines. (These bats may be negotiating the spaces between the gate bars without the use of their sonar capabilities.)

Effect of bat gates on bat activity: Overall circling to in-and-out ratios was much greater (>5X) at gated mines than un-gated mines. However, within gated mines, ratios change substantially at different times of the year. This may reflect differences in species behavior and/or developmental difference within species behavior (e.g., sub-adult vs. adult). For example, in May, bats in one gated mine circled only once to every two entrance or exits. This may be due to different species dominating the roost as they are migrating through the area. Ten-fold increases in circling events at gated and un-gated mines with maternity groups in July and August suggested that these later changes were due to sub-adults learning to negotiate the gates or avoiding potential predators. Maternity colonies of Virginia big-eared bats showed bimodal activity around sunset and sunrise in summer until lactation when activity throughout the night increases (Lacki, 1994). As sub-adults become volant, circling may be a way of practicing flight maneuvers, thus may not necessarily reflect gate effects. Adult "tutor" bats may also be contributing to the increase in circling; O'Shae (1977) suggested that adult bats fly close to their young to "coax" them to emerge.

In addition the increase in numbers of bats using the gates may physically impair their ability to navigate through the gate openings. Twente (1955) tested Brazilian free-tailed bats and showed echolocation was not used during emergence events in large colonies.

Learning may play a role in the behavior of all ages of bats, as suggested by the ten-fold increase in circling at the newly gated mine. Early in 2001 after gate installation, bats mostly entered and exited via the crack located above the gated portal, rather than the gate. Later, however, bats started to use the gated portal more than the crack. This suggested that bats over time either learned to negotiate the gate, or grew less wary of a foreign object or predator potential.

In this study, the dramatic increase in circling behavior by bats in gated mines, indicated that gate presence, at least for some species, affects bat behavior. However, several researchers have suggested that since Townsend's big-eared bats circle more than other bats before exiting their day roosts (P. Brown, R. Sherwin, and S. Altenbach, pers.comm.) this circling might be just reflect normal species behavior. Studies by Twente (1955) showed that Townsend's big-eared bats sampled for light before exiting the roost, by circling to the entrance then roosting on the cave wall and then returning to the entrance until it is dark. However, White and Seginak (1987) documented a significantly higher amount of circling, between gated and un-gated mines, by these bats before evening exits. Thus it appears that even in bats that are known to display circling, gates may increase the amount of circling.

Unfortunately, this increased circling has not been quantified for Townsend's big-eared bat or any bat species. It is not clear if this circling represents a significant energy cost for these bats, based on constrained energy budget and warrants further study. In addition, the potential for added energy costs warrants caution in installing gates with an *a priori* assumption that it will benefit bats. Recent studies for other bat species in Florida and Indiana have identified bat species that are significantly compromised by gated entrances (Ludlow and Gore 2000). Gates may provide bats protection from disturbance thus reducing stress and increasing fat storage retention, but if this is negated by the deleterious effects of expending more energy to get through gates, the net benefit for bats is lost. In addition age specific and species-specific effects may actually affect recruitment rates for populations using these mines. Sub-adults learning to fly must negotiate the gate and thus larger energy costs may be required as they may spend more time circling before exiting the gate. Species such as the Townsend's big-eared bat may rely more on eyesight to exit gates. This may lead to an increase in circling to in-and-out ratios that other bat species may not experience. Echolocation frequency differences between species may also lead to differences in the amount of circling each species may exhibit in response to bat compatible gates. Certain bat species' echolocation frequencies may be better equipped to negotiate gates.

<u>Is there an Observer effect on bat activity?</u> The relationship between observer presence and bat activity appeared to vary between mines. At two gated mines there was no consistent correlation between observer presence and high or low levels of bat activity. These mines showed variation in bat activity during observer presence but the same changes were also noted in the 9-day random sample periods. Observer effects may be reduced at these mines because of the larger numbers of bats attempting to enter/exit through the increased portal clutter caused by the gate. Bats dealing with these distractions may be less sensitive to observer presence.

In contrast, the newly gated mine showed substantial changes in activity during observer presence but the pattern is not consistent throughout the season. Changes seen during and after survey periods were not observed in the random 9-day periods. This may be due to exposure of the mine location. Observers must sit on a narrow hillside with no cover and thus may stand out to bats using the area. Thus differences in observer effect may be due to differences in mine location, bat use of mine, or mine internal structure.

Recommendations

<u>Set up a long term monitoring program</u>

Know what species of bat you have and how gates affect its behavior before you gate. If this information is not available, set up a monitoring program to gather this information and make sure your management actions are appropriate. Consider cooperating with a local University student group to assist your information gathering.

Use of equipment

Because of the different data gathered from each type of equipment, it is apparent that a combination of equipment needs to be used at each mine to provide the greatest amount of information.

TMs are ideal for collecting daily and seasonal bat activity data within the mine and can be used for up to two to four weeks without human interference. These may be the singlemost efficacious tool for monitoring on a low budget. However, TMs only record the number of hits as bats (or other animals such as birds and rodents) pass through the vertical beam, but do not record the type of activity (entering, exiting, circling, flyby). TM's need to be elevated off the mine floor or may be mounted in the side position across the mine opening to minimize rodent activity effects on event numbers. Continuous power to the event recorders is a problem and batteries must be replaced monthly or loss of power will cause a loss of data. Due to the bats' apparent "curiosity" regarding changes in the mine environment, dummy event recorder cases should be installed in each mine to habituate bats to their presence. In addition, statistical data analysis will require additional computer programs specially designed for your analysis needs. We use a SAS macro program designed by Susan Durham, Utah State University. Finally, these event recorders are easily stolen (and impossible to recoup) if adequate security is not available. 2002 Unit Cost (Trailmaster 550™) $200.

Night vision scopes are necessary to record bat activity outside the mine entrance, especially entering, circling in front of the mine, and flybys. Night vision scopes need to be available for use at all mines simultaneously. Unit Cost $2000-5000 depending on quality of scope desired.

IR video camcorders provide reliable, permanent record of bat activity at mine entrances and decrease effects of observers near mine entrances. However, maximum recording time is one to two hours with Sony Hi-8 tapes, and data must be analyzed at a later date. Approximate Unit cost for camcorder (Sony night vision™ e.g., modelTRV340 handycam) $850 with accessories, infrared spotlight (Sony HVL-IRH2™) $75.00, tapes (Sony Hi-8™) $10.00.

Eye-spy™ IR cameras also provide information about bat activity at mine entrances, to observers stationed more than 20 meters from the mine. This distance may decrease observer disturbance effects and allow observers to monitor more than one mine simultaneously. However, radio wave transmission distance limits the receiver position, and at close distances the monitor light may be a disturbance to bats. The small camera lens with its infrared light source is quite inconspicous, but an additional infrared spotlight is needed to effectively observe bat activity. Eye-spy™ camera units are somewhat fragile and bulky which makes them more difficult to transport than other IR equipment. 2001 Unit cost was $200.

Red lights can be used to facilitate the collection of data at mine entrances. However, this is the least reliable of all methods. At distances which decrease effect of observer presence, visibility of mine entrances is low, increasing the potential for observer error in accurately estimating bat entrance/exit counts and other behaviors. Unit cost was $5.00.

Anabat™ recordings in conjunction with mist-netting/harp trapping provide limited information on species identification of bats using mines and in the surrounding area. Using recordings to identify all species in the area and those using the mines is limited. Technical difficulties include distortion of ultrasound recording by the physical rock structures at and around the mine and by an inability to accurately determine exact direction and distance of a calling bat to recording equipment. In addition, lack of vocalization by bats entering or exiting mines is sometimes a problem. Bat species such as *C. townsendii* are known as whispering bats, that is their calls may be too soft or directional to be picked up by Anabat™. Thus Anabat™ recordings are not equally effective for all species of bats which may be using these mines. Similarly, not all bat species (and individuals) are subject to mist-net or harp trapping, thus both techniques probably provide only partial information on species identification for the Silver Reef Area. In addition we believe our resident Silver Reef bats may also be learning to evade these nets as a result of past experiences. Netting once per year would limit disturbance to bats and maximize species use information. Cost for netting should include nets, poles and/or harptrap but also include the need for trained personnel with rabies shots. Cost for Anabat™ detection likewise should include equipment (Anabat™ detector and laptop computer) plus training costs for interpretation of data.

Despite the inherent drawbacks of each of these sampling techniques, the combination of these techniques has improved our knowledge of bat use of these mines. However, observer effect continues to be a question in our data collection. In 2002 we changed our protocol to include a small "bullet" camera lens plus infrared spotlights at the mine entrance connected to a power source and the camcorder located 30 meters from the mine entrance. Thus we can change video tape AND monitor bat activity through the camcorder with a substantial reduction in human disturbance. The data from this field season is still being collected.
Finally, none of these techniques accurately measures changes in bat population numbers using each mine. Future studies in this area should involve radio-telemetry and banding of bats to address these questions

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